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ABSTRACT

This paper describes an investigation of some effects of group interaction and consensus on information processing behavior. When individuals were asked to assess a hypothetical situation on the basis of various sequentially received data, a definite primacy effect was observed; individuals gave more weight to data they received first. This primacy effect, however, was vitiated by group interaction. The study also showed that after group discussion and consensus individual opinions were closer to the group assessment than to the individual's original assessment. A tendency toward convergence within groups was also observed, although it was not statistically significant. Responses of the subjects were compared to the Bayesian norm and to utility and trustworthy data. A number of statistical tables and graphs summarize the findings of the study. (Author/JG)

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by

Herbert Moskowitz

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ABSTRACT

This experiment investigated some effects of group interaction and consensus on human information processing behavior. Industrial management students assumed the role of bank lending officers and were required to revise their subjective probabilities concerning an applicant's ability to repay a loan based on data received sequentially from three independent binary symmetric inquiry sources. Responses were compared to the Bayesian norm and to the utility and trustworthiness data also collected. The results showed: 1) that primacy effects, present when individuals process information alone, were vitiated in groups; 2) that after group discussion and consensus, individual opinions were closer to the group assessments than to their original assessments. A tendency toward convergence within groups was also observed after group discussion (however, not statistically significant). Utility nor trustworthiness data were related to information processing behavior.

PRIMACY EFFECTS IN INFORMATION PROCESSING BEHAVIOR - THE INDIVIDUAL VERSUS THE GROUP*

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In recent years a great deal of attention has been focused on the problem of group decision making, that is how a group of individuals with different opinions (beliefs) and preferences (tastes) make decisions. Knowledge of the psychology of this process is an important consideration in the design of Management Information Systems (MIS), as MIS reports become the data from which inferences are drawn by the decision maker (or decision making unit) and upon which decisions are based. This paper reports the results of an experiment which was concerned with one aspect of the group decision process - the effects of group interaction and consensus on human information processing behavior.[1]

Bayesian Decision Theory provides a useful and convenient framework for investigating group information processing and decision making behavior in that it permits a decomposition of the decision problem into subjective probability and utility components. Constraints on paper length preclude discussion of the theory or empirical literature. Adequate coverage, however, is found in Moskowitz (1971) and the references cited therein. In the above cited reference the

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author found that: (1) groups processed information more conservatively than individuals; (2) groups with prior problem familiarity did not exhibit significantly different behavior from unfamiliarized groups; (3) significant differences in information processing behavior occurred between sequentially versus simultaneously received information for all group types and individuals. The results of that study stimulated the following research questions that are the focus of this paper.

Research Questions

Evidence in the literature (see, e.g., Mason and Moskowitz, 1970; Peterson and DuCharme, 1967) indicates that a "Law of Primacy" operates when information received sequentially is processed by individuals. That is, one is less "conservative" with (attaches more weight to) data received earlier in a sequence than with data received later. However, when individuals are required to collectively make a judgment or give an opinion other information generating factors, absent when individuals act alone, intrude (e.g., information about the judgment of others, verbal social interaction, achievement of consensus) which may vitiate this effect. This leads to our first and principal hypothesis.

Hypothesis 1: In processing sequentially received information, primacy effects are vitiated in groups due to the generation of additional information (a consequent of interaction and consensus) which mollifies the weight attached to earlier received information.

Although a "conservative-shift" in information processing behavior of individuals or individuals comprising the group, has been observed (Moskowitz, 1971) does the group consensus truly reflect individuals' actual post-discussion judgments? That is, "Is the group induced effect on risk taking limited only to the group member's overt compliance in the group setting or does it extend to his covert acceptance when he makes post group judgments as an individual (Wallach and Kogan, 1962)? Winkler (1968) addressed this question

in his experiments which examined various consensus mechanisms for amalgamating prior subjective probability distributions. Both of the above studies found a tendency on the part of the subjects to make their reassessments closer to the group assessment than to their original assessments. Winkler also found that there was a convergence of opinion after group discussion. It is therefore appropriate to ask whether this phenomenon also occurs in information processing tasks, which leads to the second hypothesis.

Hypothesis 2: After group discussion and consensus, subjects' opinions tend to converge and their reassessments are closer to the group assessment than to their original assessments.

The Basic Models

Although a considerable tradition exists for using Bayes' law as a model for probability revision, it is useful to review several points here that are pertinent to the development which follows. Consider, for example, two mutually exclusive, collectively exhaustive hypothesis, H and H', and a subject's prior probability for these hypothesis P(H) and P(H') such that P(H) + P(H') = 1. Let there also be a series of data items that the subject might receive which are relevant to the hypothesis, D_x or $D_{x'}$, D_y or $D_{y'}$, and D_z or $D_{z'}$. The subscripts x, y, z indicate that the data is about different attributes of the situation and $D_{x'}$ represents the negation or denial of D_x, etc.. That is, given H either D_x or $D_{x'}$ should obtain. Consequently $P(D_x|H) + P(D_{x'}|H) = 1$.

Bayes' law indicates that upon the receipt of a data item, say D_x, the subject should revise his probabilities as follows:

$$\frac{P(H|D_x)}{P(H'|D_x)} = \frac{P(D_x|H) \cdot P(H)}{P(D_x|H') \cdot P(H')} \tag{1}$$

or more simply,

$$\Omega_1 = L_x \Omega_o$$

where,

Ω_o refers to the odds in favor of H over H' prior to the receipt of D_x.
Ω_1 refers to the revised or posterior odds after the receipt of D_x.
L_x represents the likelihood ratio for datum D_x.

Upon receipt of an additional data item, say D_y, the new odds are calculated by [assuming D_x and D_y are statistically independent, i.e., $P(D_x \cap D_y|H) = P(D_x|H) \cdot P(D_y|H)$]:

$$\Omega_2 = L_y \Omega_1 = L_y L_x \Omega_o = L_x L_y \Omega_o \tag{2}$$

The far right-hand equality is obtained by the commutative law of multiplication and implies that theoretically, Ω_2 is not affected by the order in which the data, D_x and D_y, are received.

There is no general way of determining the likelihood ratio for the negation of a data item (i.e., $L_{x'}$) if one only knows the affirmative L_x. However, under conditions of symmetry in which the informativeness of the affirmative is the same as that of negation, $P(D_x|H) = P(D_{x'}|H')$ and $P(D_x|H') = P(D_{x'}|H)$ and this denotes that

$L_{x'} = 1/L_x$. This symbolism represents a binary symmetric inquiry source and is summarized by the following likelihood matrix.

		Data	
		D_x	$D_{x'}$
Hypothesis			
	H	$P(D_x \mid H)$	$P(D_{x'} \mid H)$
	H'	$P(D_x \mid H')$	$P(D_{x'} \mid H')$

More precisely, a subject or group is defined to be conservative with respect to D_x if his actual (or imputed) likelihood ratio, L_x^a, meets one of the following conditions:

either

$$1 \leq L_x^a < L_x \text{ if } L_x > 1 \tag{3}$$

or

$$L_x < L_x^a \leq 1 \text{ if } L_x < 1 \tag{4}$$

It should be noted that if $L_x = 1$ a datum is totally uninformative and should have no impact on the recipient's beliefs. As L_x becomes progressively larger or smaller than 1 a datum becomes more informative and consequently should have an increased impact on the recipient. Thus L_x serves as a measure of the "degree of informativeness" of a data item.

Suppose, now, that there exists a group of individuals whose beliefs regarding the relevant states of nature (hypotheses) and the conditional probability (likelihood) matrix possibly differ, but must be reconciled. Roberts (1965) showed that the group posterior distribution could be determined by a weighted average of each individual's posterior distribution, i.e.,

$$P_G(H|D_x) = \sum_{i=1}^{n} \lambda_i \frac{P_i(D_x)}{P_G(D_x)} \cdot P_i(H|D_x) \tag{5}$$

subject to

$$\sum_{i=1}^{n} \lambda_i = 1 \text{ (prior probability weights)} \tag{6}$$

$$\sum_{i=1}^{n} \lambda_i \frac{P_i(D_x)}{P_G(D_x)} = 1 \text{ (posterior probability weights)} \tag{7}$$

where

$$P_G(H) = \sum_{i=1}^{n} \lambda_i P_i(H) \tag{8}$$

$$P_G(D_x) = \sum_{i=1}^{n} \lambda_i P_i(D_x) \tag{9}$$

and $P_G(H|D_x)$ = group posterior probability assessment of H given datum D_x

λ_i = relative weights associated with individual i's prior probability P(H), used to arrive at a group prior probability assessment (if group assessment arrived at democratically, all λ_i's would be equal).

$P_i(D_x)$ = individual i's probability of receiving message or datum D_x

$P_G(D_x)$ = group probability of receiving datum D_x

$P_i(H|D_x)$ = individual i's posterior probability assessment of H given D_x

From this, the group likelihood ratio (which is equal to the Bayesian likelihood ratio if each individual receives the same data from given information sources and processes it in a Bayesian manner) could be imputed from equation ( ).

Method

Two important features of the experimental instrument were: (1) its attempt to capture realism in the information processing task and (2) that a Bayesian solution to the problem could be calculated. Psychological experiments involving human versus Bayesian revision of probabilities almost always employ random data generating paradigms, such as dice, urns, book bags-and-poker chips, etc.. Although some may argue that such data producing vehicles provide more experimental control, they lack realism and generally require long sampling sequences to generate data of significant informativeness. Moreover, recent evidence (Beach, Wise, and Barclay, 1970) questioned the validity of the results of experiments using the book bags-and-poker chips paradigm, in that subjects, in such experiments, tend to indicate the proportion of chips in the sample as their posterior probability revisions.

Experimental Design

Subjects were given a scenario which placed them in the role of a bank lending officer who was to assess the probability that a loan applicant would become delinquent during the coming year (i.e., H = hypothesis "applicant will be delinquent," subject estimated P(H)). Three different and statistically independent binary, symmetric data sources were provided which, although fictionalized, provided objective (relative frequency) conditional probabilities (e.g., $P(D_x|H)$) based on actual historical studies of bank files.

These were (1) the bank's own internal records, (2) a credit scoring system based on the borrower's attributes and (3) a credit data service which provided retail credit information (WCDC). With the exception of its summary form and the particular numerical values used the data items are the same as those available to many bank lending officers.[2] In addition to background information the items included statements such as "This study shows that 80% of the borrowers who had never been delinquent were rated 'G' by WCDC and that 80% of those who had been delinquent were rated 'B'. WCDC has just informed you that Mr. Jones' rating is 'G'." Similar reports are developed for each of the other two sources so that the subject's subsequent information was based on three conditional probability (likelihood) matrices (Table 1).

Insert Table 1 about here

From these three sources, eight combinations of data groups can be derived and from each data group there exists six orders of presentation, giving 48 data group sequences in all. In that it was infeasible to test all data group sequences, a 3x3x2 latin-square design was formulated by randomly selecting X, Z, and Y' as the data items for presentation. This led to the following latin square design (Table 2).

Insert Table 2 about here

After reading the situational scenario the individual or group recorded his prior probability that the borrower would be delinquent on a 99 position scale (Figure 1). Then he received the first item

of information (e.g., Assignment 1 received X initially). He was given 5 minutes to consider the information, to reevaluate his previous estimate, and to mark his revised probability on a new scale. He then received the second item of information (e.g., Z) with the same instructions and finally he received the third item (e.g., Y'). Prior to the information processing task a reduced version of Kogan and Wallach's Choice Dilemma's Questionnaire (CDQ) was administered to determine the risk-taking propensity (viz, utility) of the individuals and groups (Kogan and Wallach, 1964). At the completion of the processing task the subjects reviewed the information sources and evaluated the trustworthiness of the data provided by each source on a 10 point scale. Space limitations preclude discussing the procedures employed in administering the experiments. These are, however, equivalent to those of Wallach, Kogan, and Bem (1965) in their investigation of the influence of group interaction on risk attitudes (rather than subjective probability revision), which are enumerated in the cited reference. In our experiment, all groups succeeded in reaching a consensus, and the nature of the group discussions indicated that the participants were highly involved in the tasks.

Insert Figure 1 about here

Subjects and Facilities

One hundred seventeen upper division undergraduate industrial management students at Purdue University served as subjects. The

individual and small group behavioral laboratories of the Behavioral Science Laboratories at Purdue's Krannert School was used to conduct the experiments. A detailed description of the facilities and equipment is found in Fromkin (1969).

Data

The experimental design provided for the following basic data from each subject and each group, which was composed of the same individuals: CDQ score, $P(H)$, $P(H|D_x)$, $P(H|D_x, D_z)$, $P(H|D_x, D_z, D_{y'})$, $T(D_x)$, $T(D_z)$ and $T(D_{y'})$, ($T(D_x)$ is the subject's evaluation of D on a 10 point trustworthiness scale). Since the experiments took one hour (a normal class period) excluding post discussion reassessments, such reassessments were only collected on those in Assignment 1 (Table 2).

From the subjective probability data a subject's or group's likelihood ratio was imputed from equation (1). This inferred likelihood ratio was then compared with the Bayesian standard (L_x) using the concept of the <u>accuracy ratio</u>. A subject's or group's accuracy ratio with respect to X is defined as:

$$A_x = \frac{\log L_x^a}{\log L_x} \qquad (10)$$

(See Table 1 for the complete set of Bayesian likelihoods used in this experiment). The accuracy ratio is 1.0 when subjective revision equals Bayesian revision and decreases below 1.0 as the individual or group is more conservative.

Results

Table 3 shows the cell and marginal effects in terms of mean accuracy ratios for each of the main factors controlled for: A - informativeness of data item (i.e., magnitude of Bayesian likelihood ratio), B = order of presentation, and C = group assignment.[3] Since no significant differences in the prior probabilities were observed between the groups, no attempt was made to control for this factor.[4]

Insert Table 3 about here

Analyses of variance (ANOVA) employing both 3x3x2 (Winer, 1962, p. 529, Plan 2) and 3x3 (Winer, 1962, p. 524, Plan 1) Latin Square designs were performed to analyze the data of Table 3 (Tables 4 and 5).

Insert Table 4 about here

Insert Table 5 about here

Analysis of variance assumes that the effects of the four different fixed factors are additive, and that the errors are normally distributed with homogeneous variance. In order to determine whether the conclusions were materially affected by these assumptions, the non-parametric Wilcoxon matched-pairs signed-ranks test was also applied to the data (Siegel, 1956, p. 75-83). The cumulative distributions are portrayed in Figures 2 and 3. Both ANOVA and the

Wilcoxon tests indicated a significant primacy effect for individuals (i.e., nominal groups) but not for actual groups.

Insert Figure 2 about here

Insert Figure 3 about here

An attempt was made to explain the primacy effect or lack of it in terms of individual and group evaluations of the trustworthiness of the data. No significant differences in trustworthiness were observed between groups or among data sequences.

With respect to the second hypothesis, Table 6 shows that individual reassessments were closer to the group assessment than to the original individual assessments. However, although a tendency toward convengence of individual opinion after group discussion and consensus was indicated, this was not statistically significant.

Insert Table 6 about here

Discussion

The primary purpose of this experiment was to determine whether primacy effects, observed when individuals process data, persist in actual groups. Although the results showed that primacy effects were vitiated in groups, the question still remains regarding its specific cause. It was conjectured that the group process generates

additional information as a result of three factors (i.e., 1) information about others' judgments, 2) verbal social interaction, 3) achievement of consensus) which reduce the influence of earlier received data. Determining the degree of influence of each would be useful and is being studied.

The fact that individuals' post-discussion responses more nearly reflected the group's responses and furthermore tended to converge, although expected, attests to the "influencing power" of the group. Because group's responses were more conservative than individuals, the former served as a "dampening mechanism" which constrained excursions in individual behavior, thereby exerting a conservative influence on probabilities and hence decisions (thus offsetting the effect of the 'risky shift' phenomenon observed by Wallach and Kogan (1962) and others).

The results of this experiment are limited to the specific group process used for aggregating divergent beliefs. It is not at all clear that similarly induced behavior would be generated under different amalgamation procedures. In fact, some tentative results indicate the contrary. The effect of various mechanisms for aggregating individual opinion is being explored further.

From the management side, knowledge of the psychology of these processes should help to provide appropriate strategies for the design, operation, and control of management information and decision systems.

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FOOTNOTES

(1) The author gratefully acknowledges the contributions of his research assistant, Peggy Arnett, who assisted in the preparation of the computer programs for analyzing the experimental data.

1. By group, is meant an interacting face-to-face group (i.e., involving group meeting, discussion, and consensus) with common goals (viz., team). The group information processing function includes both the forming of individual beliefs and their amalgamation into a group subjective probability.

2. The independence property among the information sources was verified with bank officials.

3. To compensate for the group biases inherent in previous comparisons of individual and group performances (Brim, et. al., 1962; Marquart, 1955) nominal groups were formed by averaging the individual accuracy ratios of the three members in each group.

4. This is consistent with previous past experimental findings. Phillips and Edwards (1966) found that conservatism was largely unaffected by prior probabilities over restricted ranges. This is also true of Peterson and Miller's (1965) results as they apply to the range of prior probabilities and likelihood ratios used in this experiment (although Peterson and Miller demonstrated that prior probabilities can be influential in other ranges).

TABLE 1

INFORMATIVENESS OF INFORMATION SOURCES

Hypothesis	Data Item		Data Item		Data Item	
	X	X'	Y	Y'	Z	Z'
H (deliquent)	.20	.80	.10	.90	.30	.70
H' (not deliquent)	.80	.20	.90	.10	.70	.30
Likelihood Ratio	1/4	4	1/9	9	3/7	7/3

TABLE 2

LATIN SQUARE EXPERIMENTAL DESIGN

Assignment	Nominal Groups			Actual Groups		
	Order of Presentation			Order of Presentation		
	1	2	3	1	2	3
1	X	Z	Y'	X	Z	Y'
2	Y'	X	Z	Y'	X	Z
3	Z	Y'	X	Z	Y'	X

TABLE 3

MEAN ACCURACY RATIOS BY DATA ITEM, ORDER, ASSIGNMENT AND GROUP

D_1 - Nominal Groups

A-Data Items Effect	B - Order Effect 1	2	3	A-Marginals
z	1.82 C_2	1.14 C_1	1.14 C_3	1.36
x	.72 C_1	.73 C_3	.69 C_2	.71
y'	.57 C_3	.47 C_2	.33 C_1	.45
B - Marginals	1.03	.78	.72	.84

C-Group Assignment Effect	Number of Groups
C_1 = .73	n_1 = 13
C_2 = .99	n_2 = 13
C_3 = .79	n_3 = 13
	n = 39

Number of Subjects (39x3) = 117
Total Group Observations (39x3) = 117

D_2 - Interacting Groups

A-Data Items Effect	B - Order Effect 1	2	3	A-Marginals
z	1.47 C_2	1.00 C_1	1.13 C_3	1.21
x	.63 C_1	.75 C_3	.82 C_2	.72
y'	.38 C_3	.46 C_2	.25 C_1	.36
B - Marginals	.83	.74	.73	.77

C-Group Assignment Effect	Number of Groups
C_1 = .63	n_1 = 13
C_2 = .92	n_2 = 13
C_3 = .75	n_3 = 13
	n = 39

Number of Subjects (39x3) = 117
Total Group Observations (39x3) = 117

TABLE 4

ANALYSIS OF VARIANCE: DATA ITEM, ORDER, ASSIGNMENT, GROUP (TABLE 3)

Source	df	MS	F	p*
Data Items (A)	2	15.42	192.49	.00
Order (B)	2	.98	12.26	.00
Assignment (C)	2	1.58	19.67	.00
Groups (D)	1	.34	4.23	.02
A x D	2	.15	1.82	N.S.
B x D	2	.23	2.82	N.S.
C x D	2	.00	.04	N.S.
Residual	4	.26	.06	N.S.
Within Cell	216	.08		

* See [Winer, 1962, Appendix B, p. 646]

TABLE 5

ANALYSIS OF VARIANCE: DATA ITEM, ORDER, ASSIGNMENT, GIVEN THE GROUP (TABLE 3)

D_1 - Nominal Groups

SOURCE	df	MS	F	P
Data Items (A)	2	8.56	1044.05	.00
Order (B)	2	1.08	131.67	.00
Assignment (C)	2	.70	85.74	.00
Between	8	2.68	326.74	
Residual	2	.37	45.5	.00
Within Cell	108	.01		

D_2 - Interacting Groups

SOURCE	df	MS	F	P*
Data Items (A)	2	7.00	46.07	.00
Order (B)	2	.13	.85	N.S.
Assignment (C)	2	.88	5.76	.00
Between	8	2.04	13.40	
Residual	2	.14	.92	N.S.
Within Cell	108	.15		

* See [Winer, 1962, Appendix B, p. 646]

TABLE 6

AVERAGE ACCURACY RATIOS AND THEIR STANDARD DEVIATIONS FOR COMPARISON OF DISTRIBUTIONS

A. Differences among original individual assessments, group assessments, & Individual Reassessments

Statistics	Orig. indiv. asses. vs group assess.	Indiv. reassess. vs group assess.	Indiv. reassess. vs orig. indiv. assess
Mean Std. Dev. t(df = 7)	8.71 4.80 4.85	2.92 7.35 1.26	9.11 10.00 2.43
p	<.01	N.S.	<.05

B. Convergence within groups

Statistics	Diff. between Std. Dev. of orig. indiv. assess. within groups	Diff. between Std. Dev. of indiv. reassess. within groups	t(df= 14)
Mean Std. Dev.	19.00 8.69	14.60 9.00	N.S.

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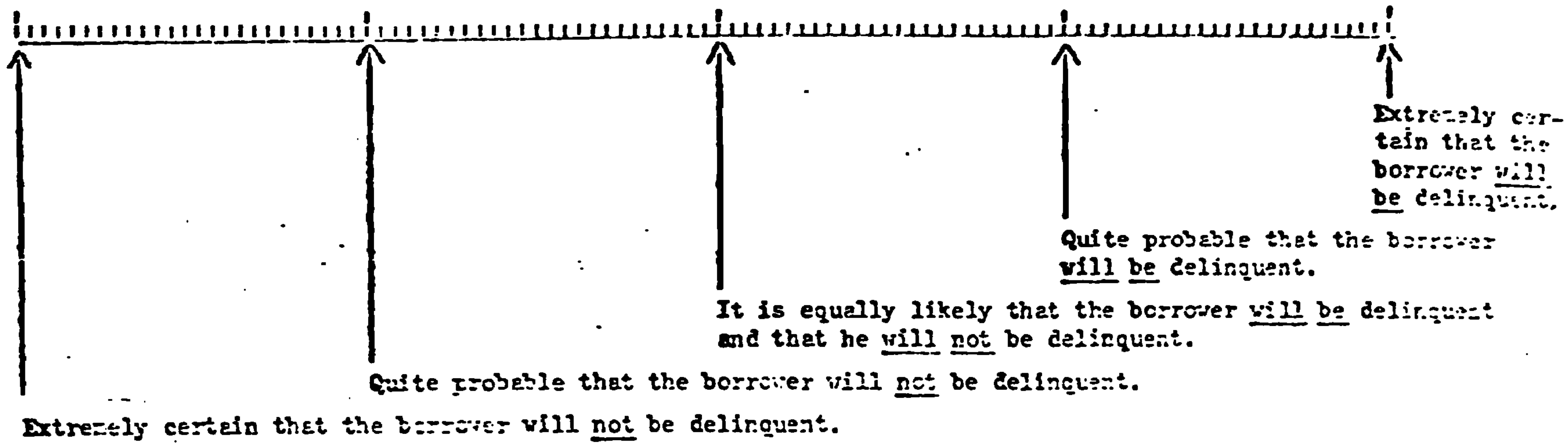

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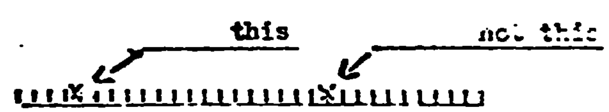
1. Place your "X" in the middle of the spaces not on the boundaries.

   Example:



2. Be sure to record an "X" each time you are asked to indicate your degree of belief.

3. Never put more than one "X" on a single scale.

STOP!

Please do not turn this page until asked to do so.

Thank you.

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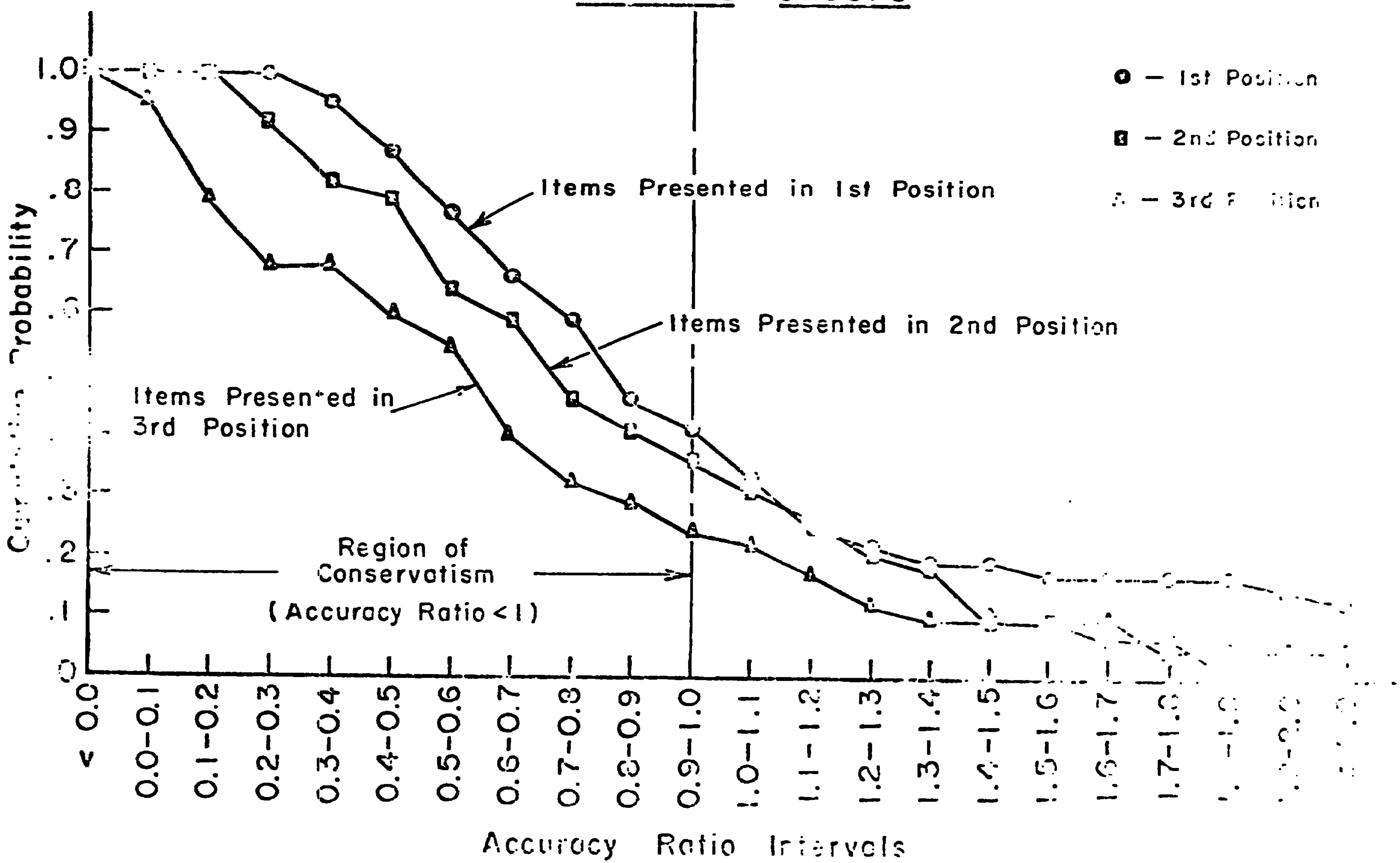
NOMINAL GROUPS



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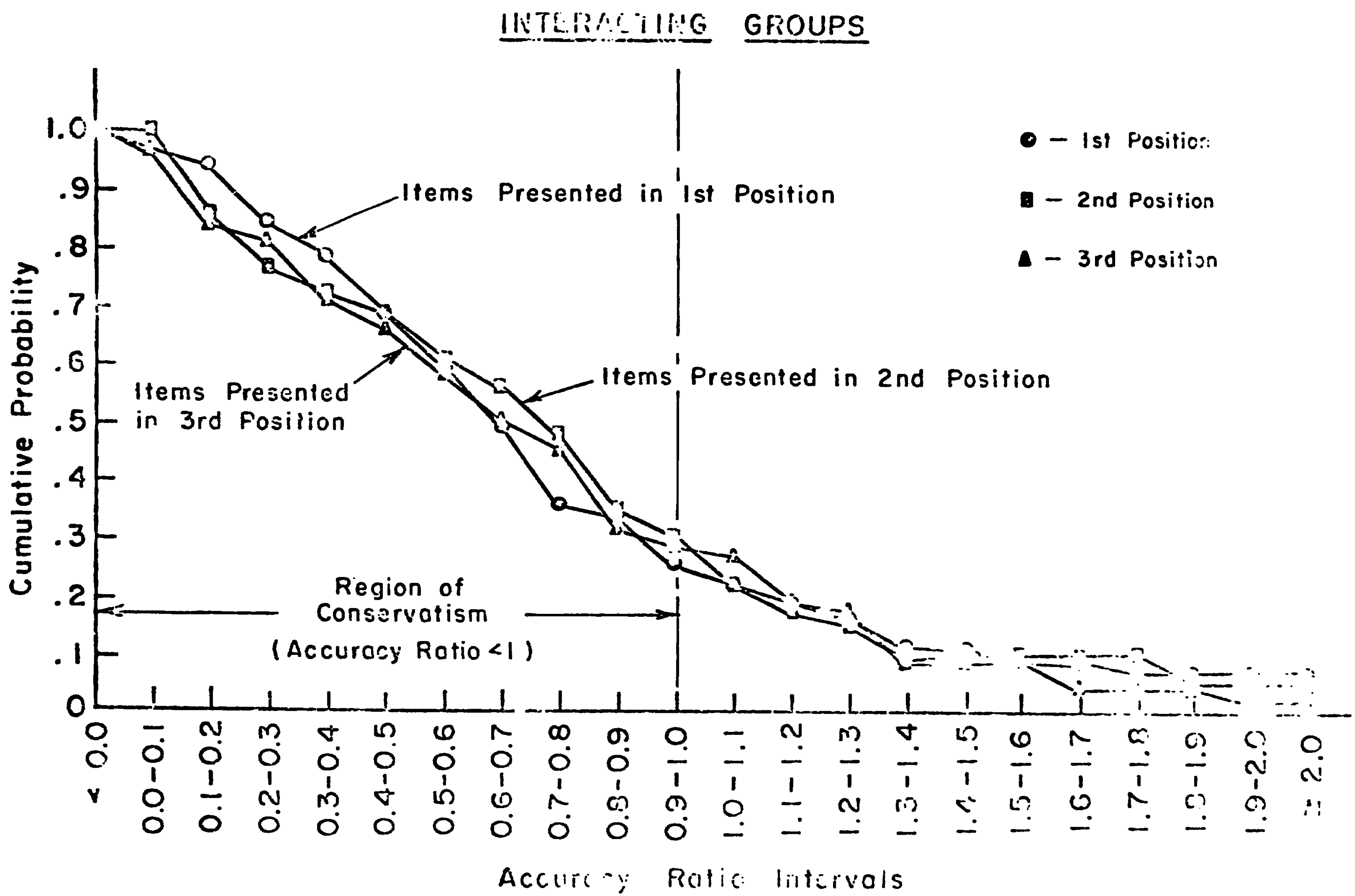

FIGURE CAPTIONS

1. Fig. 1. Measurement Scale.

2. Fig. 2. Cumulative probability distributions of accuracy ratios for individuals (nominal groups) by order of data presentation (primacy effect).

3. Fig. 3. Cumulative probability distributions of accuracy ratios for interacting groups by order of data presentation (order effect vitiated).

10-1-71

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